Turning Silk Purses into Sows' Ears: Environmental History and the Chemical Industry

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Recently, environmental historians have called for histories of the environmental damage caused by chemical companies in the era before strict federal regulation, which began in the late 1960s. This article examines how chemical companies, pollution experts, and government agencies defined the problems of pollution and sought remedies for it. With a few exceptions, until the mid-1930s chemical companies dealt with pollution problems in an ad hoc fashion, acting in response to complaints. National attention to water pollution began during the New Deal, when Roosevelt appointed a National Resources Committee and legislation was introduced that would have established federal control of water pollution. These events galvanized the industry to begin to pay systematic attention to water pollution by establishing pollution engineering positions, forming trade association committees, and organizing symposia at professional meetings.

In the early twentieth century, as the modern chemical enterprise was coalescing from a wide variety of older industries, Arthur D. Little, an expert in chemical wood pulping for paper production, created a powerful metaphor from a turn of an old phrase: chemistry, he said, turns "sows' ears into silk purses."[1] Chemists everywhere rallied to the cause of turning common raw materials and industrial by-products into valuable commodities, an activity both worthwhile and profitable.

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1. This story is told in Maurice Holland, *Industrial Explorers* (New York, 1928), 163–64.

For their part, historians of economics, business, and technology have viewed the American chemical industry as one of the major success stories of the twentieth century.[2]

At the same time, however, the chemical industry often is viewed not as a high-tech asset, but as the premier threat to human health and the earth's ecosystem. Following on the discovery of what environmental historian Craig E. Colton has called the "toxic landscape" were demands for a history of this disaster.[3] In a recent review article, Joel Tarr and Jeffrey Stine argue for the incorporation of environmental issues into the history of technology, noting, "most histories of chemical firms ignore the environmental havoc wrought by the chemical industry prior to the 1960s when federal regulatory oversight increased."[4] Yet, if business and technology historians underemphasize this story, environmental historians such as Craig E. Colton and Peter N. Skinner (who attempt to explain *The Road to Love Canal*) have focused on it directly. Because these investigations usually deal with subjects like Love Canal, it is preordained that the story of the American chemical industry is a tragedy. Indeed, Colton and Skinner argue that the chemical industry wielded its political power to defeat proposed legislation and selfishly failed to install readily available technologies to ameliorate pollution, even as public health officials and experts warned of the growing severity of the problem.[5]

In an attempt to explain why the toxicity of chemicals was not recognized for so long, Colton and Skinner accuse the industry of obfuscation while it continued to pollute and profit. Though he takes a less moralistic approach, Christopher Sellers, who has studied the evolution of industrial hygiene, argues that knowledge of chemical toxicity in the factory and plant environment was not being communicated to sanitation and public health authorities, who in turn focused on combating bacterial diseases.[6] This argu-

2. See, for example, the recent volume edited by Ashish Arora, Ralph Landau, and Nathan Rosenberg, *Chemicals and Long-Term Economic Growth* (New York, 1998).

3. Craig E. Colton, "Creating a Toxic Landscape: Chemical Waste Disposal Policy and Practice, 1900–1960," *Environmental History Review* 18 (Spring 1994): 86–116.

4. Jeffrey K. Stine and Joel A. Tarr, "At the Intersection of Histories: Technology and the Environment," *Technology and Culture* 39, no. 4 (Oct. 1998): 622–23.

5. Craig E. Colton and Peter N. Skinner, *The Road to Love Canal: Managing Waste before Love Canal* (Austin, Texas, 1996).

6. Christopher Sellers, "Factory as Environment: Industrial Hygiene, Professional Collaboration and the Modern Sciences of Pollution," *Environmental History Review* 18 (Spring 1994): 54–83.

ment overstates the understanding of toxicity among industrial researchers, who were struggling to understand how it could be defined and measured and its effects assessed. Toxic effects include acute poisoning, chronic poisoning by repeated nonacute exposure, carcinogenicity, and teratogenicity (causing birth defects). Extensive and expensive animal testing has been the standard method for determining these risks, but results have often been species-specific: chocolate, for example, is poisonous to canines. The epidemiology of exposed worker populations has been another signal of problems associated with particular chemicals.[7] Today the level of acceptable risk from chemicals in the environment is much lower than in the past, even though empirically not much has changed. Deaths from direct chemical exposure were not considered a major public health problem earlier, nor are they now. Nobody died at Love Canal—though, based on toxicological information, experts construct an abstract chemical-induced toll, primarily in the form of additional cancers.

A major oversight in the environmental account is its failure to consider the radical discontinuities that occurred in the chemical industry, environmentalism, and federal regulation during the 1960s. Between the end of World War II and 1960, the synthetic organic chemical industry had grown tremendously, primarily through the development of polymers, which are used in everything from packaging to textile fibers, from pesticides to pharmaceuticals. All of these were organic chemicals, the production of which increased by a factor of four between 1950 and 1965, when more than five hundred new organic chemical plants opened. The industry's catalogue of products numbered in the tens of thousands, with as many as a thousand new compounds created each year. The manufacture of these chemicals produced a wide variety of waste products that increased in volume with the overall growth of the industry.[8] The onslaught of both organic chemical products and their associated wastes quickly was labeled a major threat to human health and to the world's ecosystem. Rachel Carson's exposé of the insidious nature of DDT provided a case study, while Barry Commoner generalized the critique to include all synthetic chemicals as disrupters of delicately balanced ecosystems that had evolved over vast expanses of time.

7. David A. Hounshell and John Kenly Smith, Jr., *Science and Corporate Strategy: DuPont R&D, 1902–80* (New York, 1988), chap. 24.

8. David J. Sarokin et al., *Cutting Chemical Wastes: What 29 Organic Chemical Plants Are Doing to Reduce Hazardous Wastes* (New York, 1986), chap. 1.

Independent of both the growth of the organic chemical industry and popular fears of chemical toxicity, the most important event of the mid-1960s was the passage of two pieces of federal legislation: the Water Quality Act of 1965 and the Clean Water Restoration Act of 1966. These two bills ended thirty years of debate over control of the nation's waterways and ushered in the era of federal regulation and resource use to address water pollution. Nearly $4 billion was provided to build municipal water treatment plants for domestic sewage, but the chemical industry expected that, when public pollution was eliminated, private pollution would be targeted next. Although assessing the problems caused by chemical wastes and defining methods of treatment were considerably more complex than for domestic sewage, in the late 1960s and early 1970s additional federal and state legislation, now strongly supported by public opinion, required much more extensive treatment of chemical wastes. These events, especially the 1965 and 1966 acts, were the culmination of thirty years of efforts by industry, experts, and government to address the problem of water pollution. An earlier resolution did not occur because of states' rights attitudes in Congress—especially among legislators interested in sustaining racial segregation—and insufficient funding of sewage treatment facilities. Lyndon Johnson swept away both of these obstacles with the Civil Rights Act of 1964 and with federal funding for his Great Society programs. The issues and problems of water pollution had been obvious for decades; the solution awaited changes in the larger arena of American politics.

Though the process has not been well documented by historians, from the mid-1930s to the mid-1960s, the chemical industry had constantly wrestled with pollution issues. There was a general understanding that pressures for cleaner air and water were going to increase in the future. Because complete elimination of discharges was not economically or technologically feasible, the chemical industry sought ways to assess the severity of pollution as well as cost-effective means of amelioration. The industry did spend some money on pollution control, but it is difficult to judge whether this discretionary spending of corporate profits was too much or too little. In the absence of a firm regulatory presence, industrial benevolence had limits. The massive problem of untreated domestic sewage significantly undermined industry incentives to clean up its part of the mess. Not until public funds took care of municipal sewage in the late 1960s did society finally demand that industry follow suit.

From the beginning, the chemical industry generated wastes. Ironically, it was experimentation with coal tar wastes that led to the development of the modern organic chemical industry. The use of by-products to make valuable compounds is an important aspect of chemical technology; however, the idea that all waste can be profitably utilized, though tempting, has not proved accurate.[9] In the 1930s, when *Industrial and Engineering Chemistry* encouraged readers to advertise available wastes in the journal, hoping that users could be found, the feature did not catch on and soon was discontinued.[10] A more sophisticated approach to profitable waste elimination is to increase the yields of desired products, thereby decreasing the amount of by-products. For most chemical production processes, improvements in yield occur over time as a learning curve of experience accumulates or through occasional breakthroughs in process technology.

When wastes cannot be used, sold, or eliminated, they are treated to minimize the degradation of air and water quality. This has been the least desirable alternative, because it represents increased investment and operating costs for any plant. Major contributors to the pollution problem are the process aids used in chemical reactions, usually acids or solvents; they provide a medium for the reactions and often become so diluted or contaminated that reprocessing is very expensive.

Like the generation of waste, problems of pollution existed in the chemical industry from its beginning.[11] Early attempts at remediation usually were inspired by local complaints or lawsuits. The recognition that pollution required ongoing and systematic attention began at the state level, and in some professional organizations, in the 1920s. The Pennsylvania Sanitary Water Board organized industry-supported research on reducing tannery wastes in 1924; created a Pulp and Paper Waste Disposal Committee in 1926; forced by-product coke oven operators to eliminate phenol discharges in 1928; and set up a Bituminous Coal Mine Drainage Board in 1929. In 1926, the American Petroleum Institute created a national committee to study oil pollution of streams and a year later published a manual for the disposal of refinery wastes.[12] At its annual meeting in December 1931, the Amer-

9. In 1931 pollution engineer Edmund B. Besselievre said, "It is a delusion and a snare to start out with the idea of recovering sufficient valuable product from waste to make a proposition self supporting." Edmund B. Besselievre, "Industrial Waste Disposal as an Engineering Problem," *Chemical and Metallurgical Engineering* 38, no. 9 (Sept. 1931): 503.

10. The call went out in "The Economic Importance of Waste Treatment to the Industries," *Industrial and Engineering Chemistry, News Edition*, 14, no. 22 (20 Nov. 1936): 445–46. Subsequent issues included offers of waste such as calcium sulfate.

11. R. W. Hess and C. J. Carney, "Organic Chemicals Manufacture," *Industrial and Engineering Chemistry* 44, no. 3 (March 1952): 494–97.

12. W. L. Stevenson, "The Sanitary Conservation of Streams," *Transactions of the American Institute of Chemical Engineers* 27 (1931): 9–30.

ican Institute of Chemical Engineers sponsored a session on water pollution. The federal government played a minor role in water pollution research (through the U.S. Public Health Service [USPHS]) until Franklin Roosevelt's New Deal.

DuPont Confronts Water Pollution

To assess the response of the chemical industry to water pollution, which was the major issue[13] from the 1930s until the advent of strict federal regulation in the mid-1960s, I draw heavily on the experience of the DuPont Company, which probably represents a best-case scenario. DuPont has long embraced a faith in rational, especially scientific, approaches to problem solving. It also has valued being a responsible corporation and having a positive public image, especially among policy- and opinion-makers. DuPont also was the largest and most successful American chemical company. On a more practical level, DuPont archival documents are accessible, making it possible to investigate internal attitudes toward pollution control.

Pollution control engineering appeared on the organization charts of DuPont in 1936.[14] In the same year, the Manufacturing Chemists' Association (MCA) established a Water Pollution Committee. These events followed the introduction into Congress of bills to establish federal control of pollution of the nation's navigable waterways. In addition, in June 1935 President Roosevelt established, by executive order, a National Resources Committee, which included an Advisory Committee on Water Pollution headed by Abel Wolman, chief engineer of the Maryland Department of Health and professor of engineering and of hygiene and public health at Johns Hopkins University.[15]

Working quickly, the Wolman committee began with a survey of pollution conditions and existing legislation in all states. The committee discovered that many states were faced with increasingly serious pollution problems; that there was little application of uniform standards of water quality; that insufficient effort was being made to

13. Air pollution came from so many sources that the chemical industry was not particularly singled out for criticism. See *Proceedings of the First National Conference on Air Pollution* (Los Angeles, 1949).

14. Dow Chemical also took action: in 1936, Dow hired Thomas J. Powers, who had been an engineer for Michigan's Stream Control Commission. See E. N. Brandt, *Growth Company: Dow Chemical's First Century* (Lansing, Mich., 1997), 265.

15. U.S. National Resources Committee, Special Advisory Committee on Water Pollution, *Report on Water Pollution* (Washington, D.C., 1935).

protect public health, water fowl, and fish life from the effects of industrial and domestic waste; and that many states were lacking in the legislation to cope with existing conditions.

To begin to address this situation, the committee recommended that the federal government coordinate interstate cooperation organized around river systems, beginning with a pilot project in the Potomac River basin. The outcome of this experiment would determine whether or not federal legislation was needed. Wolman and his committee of experts clearly did not believe that the politicians in Washington should be setting the agenda or even paying the bill. In an address to the American Institute of Mining Engineers, Wolman argued against continued federal funding for controlling acid pollution from coal mines, even though it was probably the greatest source of stream pollution in the United States. He believed that if industry accepted taxpayers' money, eventually politicians would pass restrictive legislation that might go far beyond measures that the experts would recommend.[16]

This cautious approach apparently was not enough for proponents of stronger federal regulation of water pollution. Early in 1936, Senator Augustine Lonergan (D-CT) introduced a bill "to prevent pollution of the navigable waters of the United States," which also covered all the tributaries of navigable waterways. Federal control would be exercised by a board appointed by the president, which would set up district boards—based on watersheds—that would set standards of water purity and prosecute polluters. The bill apparently received considerable support within Congress and from sportsmen's associations such as the Izaak Walton League, a fishermen's organization.[17] Wolman, who in 1931 noted the power of such organizations, stated:

> [T]he last ten years has seen a remarkable growth of organizations militantly interested in the cleaning up of streams for the future protection of fish and game. Their methods have not always been impartial or informed, but their motives have been good. . . . They still have to learn and decide whether the destruction of small numbers of game fish should be avoided by the expenditure of thousands of dollars for the treatment of industrial wastes.[18]

16. Sidney J. Kirkpatrick, "Who's Responsible? Who's to Pay?" *Chemical and Metallurgical Engineering* 44, no. 3 (March 1937): 1.

17. The history of this legislation is in "The DuPont Company and Trade Waste Disposal," Accession 1662, box 77, Hagley Museum and Library, Wilmington, Del. [hereafter cited as Trade Waste Files].

18. Abel Wolman, "Stream Pollution," *Chemical and Metallurgical Engineering* 38, no. 9 (Sept. 1931): 505.

Chemical industry executives opposed the bill and worked through their trade association to help defeat it. When Congress passed a watered-down bill authorizing the formation of a Division of Stream Pollution within the USPHS, President Roosevelt pocket-vetoed it.[19] Nevertheless, this episode prompted at least the more progressive chemical manufacturers to begin to pay more attention to pollution evaluation and control.

The management of pollution by federally empowered sanitary district boards, the industry believed, would lead to uniform water quality standards, the enforcement of which would require cleaning up streams that no one was complaining about, at considerable expense. To present its position to Congress, the MCA hired Sheppard T. Powell, the same consultant who had advised the National Resources Committee on Water Pollution. A colleague of Wolman, Powell was a noted authority on water pollution who also taught at Johns Hopkins and was active in public health in Maryland. He was also chair of the joint Committee on Water Pollution of the American Society of Civil Engineers and the American Institute of Chemical Engineers. In his testimony, Powell stated that the chemical industry was aware of "the increasing seriousness of stream pollution *in some sections* [emphasis added], and the desirability for remedial measures." He noted that the industry had spent $22 million ameliorating pollution, which represented about one percent of the industry's total investment. In spite of this effort, he admitted that the great rivers of the Northeast and Midwest, primarily, were still a problem. Much of the blame fell on municipalities that dumped half of their sewage untreated directly into waterways. In addition, cities and industries had not cooperated enough "in the creation of properly organized programs for the coordination of their combined interests." Powell also noted that uneven pollution regulations and enforcement had "resulted in economic inequalities, thereby retarding progress that might otherwise have been made." In a contradictory argument, he also maintained that "control of stream pollution in some states with regulatory laws is not better than in other states without such legislation." His point was to demonstrate the futility of solving problems through legislation alone. One reason for the present situation, he noted, was "the absence of any satisfactory method of treatment for a number of industrial wastes."[20] In this era, the country's

19. U.S. National Resources Committee, Special Advisory Committee on Water Pollution, *Water Pollution in the United States: Third Report of the Special Advisory Committee on Water Pollution* (Washington, D.C., 1939).

20. "Statement of Sheppard Powell," appended to Warren W. Watson to Member Executives, 25 March 1936, Trade Waste Files.

chief expert did not see any simple means of attacking industrial water pollution. He obviously saw no conflict of interest in simultaneously advising the government committee and representing the chemical industry. The experts and the industry saw the matter in similar terms.

The Lonergan bill led to the establishment of a Water Pollution Committee by the MCA.[21] The chair of the committee was Walter S. Landis, a respected mechanical engineer who was vice-president of the American Cyanamid Company, a major producer of fertilizer.[22] The other members of the committee were Ivan F. Harlow, plant manager at Dow Chemical; Albert A. Backus, vice-president of the U.S. Industrial Alcohol Corporation; J. J. Healy from the Merrimack Chemical Company; and Frederick "Zip" Zeisberg, a prominent chemical engineer from DuPont.[23] Zeisberg was selected by DuPont's president Lammot du Pont over another less eminent engineer who had experience in the field. Landis informed du Pont that "it will be a great pleasure to have [Zeisberg] assist in the development of this project along sane and sensible lines."[24]

At the first meeting of the committee in May 1936, Landis distributed a draft resolution for use in congressional testimony, to be given a few days later, that had been adapted from one approved by the American Petroleum Institute. The document framed the issue as optimizing the *utilization* of waterways within the mix of water supply, transportation, drainage, waste disposal, water power, food supply, and recreation.[25] This was a standard approach dating back to the conservation movement during the Progressive Era.[26] Because the optimal mix for each stream would be different, it was argued that regulation and control should be exercised at the state and local level or through special interstate compacts. The MCA supported a substitute bill that would have established a Division of Stream Pollution Control within the USPHS that would perform only studies paid for by state or municipal clients.

The Water Pollution Committee next began to work on a resolution to be passed by the MCA based on a model resolution from the Pulp

21. Frederick C. Zeisberg, "Manufacturing Chemists Water Pollution Committee," 18 May 1936, Trade Waste Files.

22. "Chemical Industry Medal," *Industrial and Engineering Chemistry* 28, no. 12 (Dec. 1936): 1468–76.

23. On Zeisberg, see Hounshell and Smith, *Science and Corporate Strategy*, 277–78.

24. W. S. Landis to Lammot du Pont, 10 April 1936, Trade Waste Files.

25. Zeisberg, "Manufacturing Chemists Water Pollution Committee."

26. Robert Sperr Weston, "Water Pollution," *Industrial and Engineering Chemistry* 31, no.1 (Nov. 1939): 1311–15.

and Paper Manufacturers' Association.[27] The resolution was a very conservative document that recognized federal authority only in the case of interstate waterways that were not managed by interstate compacts. The heart of the resolution was: "No regulatory program shall include a prohibition against the discharge of any waste into any stream or waterway unless there is available a practical and reasonable method of treatment which may be employed to control the discharge." The meaning of this sentence, Zeisberg surmised, was that only treatable wastes need be treated.[28]

Zeisberg's views were informed by an engineering model of utility and an ardent states' rights philosophy, perhaps acquired while he was a student at the University of Virginia. He suggested to Lammot du Pont that the MCA brief include the statement that "The best use of any waterway is the use which brings the greatest good to the greatest number without at the same time infringing on the constitutional rights of any citizen."[29] He expressed similar views to an outdoorsman colleague after attending a meeting of the Delaware Fish & Game Protective Association.[30] Although professing to be an angler, Zeisberg did not belong to the association as, apparently, his colleague did.[31] Zeisberg informed him that he was disappointed that the meeting was made "the occasion for the dissemination of biased political propaganda" in favor of the Lonergan bill:

> This bill was drafted by a New Dealer and under the guise of accomplishing a cleaning up of the streams of this country, which every right thinking man agrees should be done within reason, would take away all states' rights in this matter and center the control of virtually every stream and watercourse in this country in Washington. . . . It is no stretch of the imagination to say that a man could be prosecuted for spitting in his own spring. . . . I do not think it is fair to tax the entire State of Delaware so that the streams . . . which might contain fish can be fished by the comparatively few per cent of the population who would be interested in fishing. Each state must make up its own

27. Warren Watson, "Water Pollution," 21 July 1936, Trade Waste Files.

28. Frederick Zeisberg to B. D. Beyea, "Water Pollution," 24 July 1936, Trade Waste Files.

29. Frederick Zeisberg to Lammot du Pont, handwritten note, 19 May 1936, Trade Waste Files.

30. F. C. Zeisberg to Luther D. Reed, "Stream Pollution," 28 April 1937, Trade Waste Files.

31. A 1937 "who's who" of chemists listed fishing as the second most popular hobby of chemists next to golf. One-third of chemists played golf and one-fifth fished. Williams Haynes, ed., *The Chemical Who's Who, Volume II 1937* (New Haven, Conn., 1937).

> mind just how far it wants to go in incurring the expense of cleaning up its streams. In doing this, it must consider the cost of cleaning up and balance this against the advantages obtained. *There are unquestionably some streams in the country which might as well be recognized as sewers and used for that purpose only.* [Emphasis added.]

Lammot du Pont, who was on the MCA executive committee, took a more moderate stance than Zeisberg. He successfully modified the original MCA resolution so that it applied only to existing plants; new plants could discharge wastes only after they had been rendered "innocuous."[32] DuPont was, he believed, doing a reasonable job of not releasing "objectionable" wastes, was studying methods of treating them, and was, in one case, changing a manufacturing process to eliminate a waste product.

Zeisberg saw an opportunity to use the MCA committee for more than coordinated lobbying. To find out what the rest of the industry was doing with regard to pollution, he requested that the MCA committee send out a survey to its members asking about local requirements for treatment and about what steps member companies had taken to treat wastes. His proposal was adopted and several hundred questionnaires were sent out. DuPont took sixty-six, one for each plant.[33] This exercise led to an inventory of the company's and the industry's pollution control activities.[34] The DuPont definition of waste problems targeted those that involved large quantities of effluents or that were offensive to neighbors. The survey revealed that the bulk of DuPont's wastes were acids. It disclosed two serious problems that were being addressed by their respective departments and predicted that three other plants would face problems in the future. Zeisberg noted that the electrochemical plant at Niagara Falls (acquired by DuPont in 1930) had solved a serious problem by installing a disposal system, apparently setting an example for other companies in the area. Although the wastes from the Belle plant on the Kanawha River in West Virginia were said to be "no serious problem," they included acid sludge from benzol washing, hydrocyanic acid, nylon intermediates waste, and tar.[35] At the time of the survey, the sheer

32. Lammot du Pont to F. C. Zeisberg, 10 June 1936; F. C. Zeisberg to B. D. Beyea, 30 July 1936; and Lammot du Pont to Warren Watson, 30 July 1937, Trade Waste Files.

33. Zeisberg, "Manufacturing." The questionnaire is included in Watson, "Water Pollution"; the DuPont plant list is in F. C. Zeisberg to Warren Watson, 22 Sept. 1936, Trade Waste Files.

34. "DuPont Company and Trade Waste Disposal," Exhibit A.

35. The first process used to make hexamethylenediamine—an unusually complex material for 1930s technology—had a yield of only 50 percent. See Hounshell and Smith, *Science and Corporate Strategy*, 262–74.

bulk of wastes and their offensiveness, not their potential toxicity, defined them as problems.

DuPont was confronting toxicity *in* its plants with a new toxicology laboratory that had been established in 1935. Instead of having only a doctor who would administer industrial hygiene, DuPont was going to do its own research and testing. The immediate cause was the outbreak of bladder tumors among dyestuffs workers, but the company had been contracting out toxicological testing for several years. Dow also created a similar facility at about the same time.[36] Even in the plant, toxicity was seen to be a function of concentration, with dilution being the answer to worker exposure. Dilution also was seen as the method for reducing the toxicity of wastes, a remedy employed by many companies.

Including the DuPont data, the MCA survey yielded data on 230 plants owned by eighty-seven companies. Interested in upstream as well as downstream pollution, the survey's authors requested information on whether or not plants had to pretreat process water before using it. Only thirty-one plants reported pretreatment—eighteen for sewage and thirteen for industrial wastes. (This indicated to Zeisberg that municipalities were bigger polluters than industry.) Treatment of this incoming pollution cost the industry $2.5 million in investment and $350,000 in annual operating costs. At the exit end, eighteen plants had altered processes to avoid discharge of wastes, representing $950,000 in investment and $80,000 in operating costs, and forty-seven plants had installed waste treatment equipment representing $3 million in investment and $400,000 in operating costs.[37] Added together, pollution investment was about 4 percent of the industry's total investment, and pollution expenses took about one percent of net profits.[38] This level of spending was small compared to the overall scale of the problem. In 1938 the Natural Resources Board estimated that the cost of treating industrial wastes would be "between three-quarters of a billion and a billion dollars, and operating charges would be upward of half a billion dollars annually."[39] The chemical industry's share of this bill would have been a major burden on that industry, which had $1.5 billion in plant investment, roughly $1 billion in sales, and $100 million in net profits.

36. Ibid., chap. 24.

37. Zeisberg to du Pont, 15 April 1937, Trade Waste Files.

38. For statistics on the chemical industry see "What is Chemical Industry?" *Chemical and Metallurgical Engineering* (Sept. 1939), 540–71.

39. Sheppard T. Powell, "Creation and Correction of Industrial Wastes," *Industrial and Engineering Chemistry* 39, no. 5 (May 1947): 567–68.

At the same time the cost of treating municipal sewage was estimated to be $1 billion.[40] At the national level, pollution abatement would have cost over 2 percent of gross national product. There appears to have been considerable consensus that America's waterways needed attention, but the price of a total clean-up was too high. The question then became: what could be done to make significant improvements?

This question interested Lammot du Pont, who devoted considerable thought to it. Best known as the DuPont president who generously supported the fundamental research program that led to the discovery of neoprene (1930) and nylon (1934), the latter the most important event in the history of the company,[41] Lammot du Pont demonstrated in his approach to pollution the same combination of vision and horse sense he had exercised with regard to research. He recognized that public and government concerns over industrial waste were only going to increase: "It behooves the foresighted manufacturer, therefore, to anticipate this trend and to be ready for drastic legislation when, or even before, it comes."[42] He also knew that, as head of a radically decentralized organization, his power to lead was limited. To focus the attention of product division managers on pollution, Lammot du Pont supported the appointment of a chemical engineer as an internal trade waste consultant to coordinate efforts across divisions.[43] The Engineering Department appointed Harry L. Jacobs, an Iowa State chemical engineering graduate with a decade of experience at DuPont, to the newly created post. To encourage the cooperation of product division heads, the company's executive committee passed a resolution stating, "the Committee considers this subject one of major importance and one which should receive continuous study of the same type as is applied to safety work and fire protection."[44] Beginning in World War I, worker safety had become a keystone of DuPont employee relations. Lammot's predecessor, his older brother Irenée, was a safety evangelist preaching that accidents were a major cause of industrial and national waste and inefficiency. By the 1930s, safety was indeed serious business at DuPont.

40. *Water Pollution in the United States: Third Report*, 2.

41. Hounshell and Smith, *Science and Corporate Strategy*, chap. 12.

42. "The DuPont Company and Trade Waste Disposal."

43. L. du Pont to the Executive Committee, "Trade Waste Disposal," 25 Aug. 1938, Trade Waste Files.

44. Chief Engineer, Engineering Department to Heads of Departments, "Trade Waste Disposal Problems of the DuPont Company," 19 Oct. 1938, Trade Waste Files.

The demonstrable and continuous progress the company had made with accident prevention, according to Lammot du Pont, was enhanced by the development of quantitative measures such as fatality rate (deaths per million worker-hours), frequency rate (major injuries per million worker-hours), and severity rate (days lost per thousand worker-hours). Beginning in the late 1920s, interplant competitions led to awards based on safety performance.[45] Observing the enthusiasm with which safety was pursued in DuPont plants, Lammot du Pont hoped to develop a similar approach to pollution. He suggested determining annual amounts of "objectionable" discharge from each plant:

> This would make a very bad showing for all plants at the start, but would leave much room for improvement, which perhaps as years went by, would be conducive to more enthusiasm. Perhaps Mr. Jacobs could devise some more logical and simpler method of pollution measuring. My idea is to get some interest and pep introduced into the subject of prevention.[46]

Jacobs and the Engineering Department did attempt to develop quantitative measures of pollution, such as a severity factor that measured the volume of effluent multiplied by the parts per million of pollutants. The goal, apparently, was to dilute effluents down to acceptable concentrations.[47] Disagreements occurred, however, over what stream flow levels to use (average or drought) and whether or not universally acceptable criteria could be set. One engineer expressed his exasperation about endless debate within DuPont over developing suitable criteria:

> In initiating this activity, a number of arbitrary assumptions have to be made, which no doubt will be modified as we go along. This whole problem of pollution is so far from being susceptible to rational calculations that, necessarily, comparisons between locations will be somewhat academic. What we hope to accomplish is substantial or appreciable progress, particularly at the locations where conditions call for considerable improvement.[48]

45. "Development of Accident Prevention Work in E.I. Du Pont de Nemours & Company," 16 Sept. 1932, Accession 1615, box 8, Hagley Museum and Library.

46. Lammot du Pont to J. Thompson Brown, 30 Oct. 1939, Trade Waste Files.

47. C. Lalor Burdick, Assistant to the President to R.D. Moore, "Trade Waste Disposal," 19 Dec. 1939, Trade Waste Files.

48. R. D. Moore to C. L. Burdick, "Trade Waste Disposal," 3 Jan. 1940, Trade Waste Files.

Water Pollution from the New Deal to the Great Society

While DuPont struggled to determine methods to assess pollution, no federal stream pollution bill was enacted and, after 1936, growing political opposition to Roosevelt and federal power effectively ended the New Deal. Though a strong stream pollution statute would have enhanced FDR's increasing attacks on big business, embodied in the Temporary National Economic Committee and vigorous antitrust prosecution, the huge problem of untreated municipal sewage undermined any attempt to blame stream pollution on industry alone.

Although the regulatory threat subsided, industry concern about pollution continued, as demonstrated by a 1939 symposium sponsored by the Industrial and Engineering Division of the American Chemical Society. In a preface to the symposium papers, the editor stated:

> Civic pride, economics, and business hound waste with a single thought—change and prevention. Legislation has joined the pack and wasteful America is turning more attention toward conservation of materials. . . . [W]hether profitable or profitless, utilization or disposal, waste elimination should be undertaken. Chemists and chemical engineers will measure up to the requirements of the opportunity afforded.[49]

Any momentum that pollution control was gaining was shunted aside by World War II, which made old problems worse and created new ones. The emphasis on maximum production led to operating plants above capacity, usually lowering efficiency and creating more waste products. A postwar report in *Chemical and Metallurgical Engineering* noted that the process industries had been warned in 1931 that "they must take action to prevent further pollution." Yet, "after nearly 15 years, however, conditions have not improved, rather they have become more aggravated than ever due to war activity. Significantly, public clamor for clean streams has forced anti-pollution legislation to a number one spot for postwar action."[50]

Pollution, it was now believed, could be attacked with the same methods that had won the war. Indeed, massive government funding of wartime industry had included pollution control technology. The

49. "Abhor Waste," *Industrial and Engineering Chemistry* 31, no. 11 (Sept. 1939): 1310.

50. "Industrial Waste: An Important Factor in Process Planning," *Chemical and Metallurgical Engineering* (Aug. 1945), 117.

synthetic rubber program, for example, included $14 million for waste treatment.[51] At the Hanford plutonium plant in Washington, preliminary studies were done on the impact of reactor effluent on salmon in the Columbia River.[52] Overall, World War II expanded the role of the federal government far beyond the New Deal. Great achievements in radar, synthetic rubber, and atom bombs had been made through government leadership, combined with the expertise of industry and universities. Surely, pollution could be defeated by the same techniques that had won the war. Walter Murphy, editor of a special edition of *Industrial and Engineering Chemistry* devoted to industrial wastes, wrote:

> The dawn of the Atomic Age with its social, political, and economic implications has served to stimulate the somewhat latent desire on the part of the chemist and chemical engineer to enter more actively into the life of the nation. . . . Scientists have exerted tremendous influence in shaping legislation in such matters as the control of atomic energy and a national science foundation. What else can we do?[53]

The answer, of course, was that they could tackle pollution problems.

At DuPont, Lammot du Pont, now chairman of the board, expressed some disappointment with the company's immediate postwar pollution control efforts. The proceedings of a 1946 internal symposium gave "the appearance of a lot of talk and no action."[54] The internal consultant, Jacobs, explained that he was still developing measures to prioritize the company's various pollution problems. He also complained that he was not exactly clear about the specifics of the company's policy. Lammot du Pont commented that Jacobs had focused on the most difficult and largest problems, and suggested that he instead attack the easiest first because "the cost can be computed and is not excessive according to the company's general policy. . . ." Exactly what that general policy was is never stated, but he continued to push even when there were no immediate crises. In a 1947 memo to an executive committee member, he argued, "While there is no important cloud on the horizon with regard to stream pollution, as far as

51. Powell, "Creation and Correction of Industrial Wastes," 566.

52. Communication (Sept. 1999) from Michael Joshua Silverman, who is writing a dissertation on the nuclear industry and the environment.

53. Walter J. Murphy, "Industrial Wastes: A Chemical Engineering Approach to a National Problem," *Industrial and Engineering Chemistry* 39, no. 5 (May 1947): 557.

54. Lammot du Pont to E. G. Ackart, 8 May 1946, Trade Waste Files.

we are concerned, I am very fearful that at some time in the future, we will be up against it pretty hard."[55] He also announced that another engineer had replaced Jacobs.

Confirming Lammot du Pont's prediction, Congress began to consider new stream pollution bills soon after the war ended. In 1948, a Water Pollution Control Act became law. It was similar to the moderate bills of the 1930s: although the new legislation did provide federal funding, most of its provisions were for planning and research. The bulk of federal funds went to municipalities in the form of low-interest loans to assist with the construction of sewage treatment plants.[56]

After World War II, American cities began a comprehensive and expensive campaign to clean up urban waters. This effort shifted the balance of responsibility for remaining pollution toward industry. *Chemical and Metallurgical Engineering* noted these trends:

> Since sewage treatment is a fairly well established procedure and since there is a favorable outlook for government financial aid, it will be only a matter of time until most communities of any size will have treatment facilities. Undoubtedly, this alone will provide a tremendous stimulus toward forcing industry to clean up its waste, for when public funds are spent to protect the natural resources of a community it is certain that damage from any other source will be firmly opposed. No longer can industry rely on public apathy to allow them to ignore this problem.[57]

The estimated cost of cleaning up America's streams continued to be high enough to intimidate industry. In 1951, the U.S. Public Health Service estimated that the annual cost of cleaning up industrial wastes ($4.5-$7.5 billion) had surpassed that of treating municipal waste ($4.5 billion), a total of about 2 percent of gross national product.[58] At that time, the total plant investment of the chemical industry was about $10 billion, sales were $20 billion, and total pretax profits were $3 billion. The MCA reported that the industry was spending about $40 million annually on pollution control, or more than one percent of profits.[59] At that rate, the industry never would put a serious dent

55. Lammot du Pont to W. F. Harrington, 1 April 1947, Trade Waste Files.

56. John A. Blatnik, "History of Federal Pollution Control Legislation," in *Industrial Pollution Control Handbook*, ed. Herbert F. Lund (New York, 1971).

57. "Industrial Waste," 119.

58. "Liquid Industrial Wastes," *Industrial and Engineering Chemistry* 44, no. 3 (March 1952): 467.

59. "MCA Protests Pollution Stand," *Chemical and Engineering News* 32 (1954): 3361.

in overall waste disposal. As in the 1930s, industry tried to determine how much it could comfortably spend and at the same time make an impact on the overall problem.

The experience of DuPont sheds some light on how much companies were willing to spend. In 1952, DuPont stated that over the past decade it had spent $2.5 million per year on pollution abatement.[60] At the time, the company's investment and annual sales were each about $1 billion. Operating earnings were about $125 million, so pollution costs were 2 percent of profits and investment.[61] Between 1952 and 1957, pollution spending doubled to $5 million per year.[62] By 1965, DuPont's investment in pollution-control facilities had reached $77 million ($41 million for water and $36 million for air), representing 2.8 percent of the total. At the product division level, however, several divisions had pollution abatement facilities, representing 7 percent of investment.[63]

As in the past, industry continued to seek methods for assessing levels of pollution. Traditionally, industrial wastes had been converted to domestic sewage equivalents. For example, in 1952 Willem Rudolfs of the Sanitary Engineering Department of Rutgers University calculated that the pulp and paper industry created an amount of waste equivalent to that generated by 43.6 million people.[64] The conversion factor in this analysis was biological oxygen demand: the amount of oxygen needed to decompose organic compounds in the water. A major shortcoming of this method was that it did not account for toxicity, especially to aquatic life.

In an attempt to determine the toxic effects of water pollution, DuPont in 1948 helped fund an ecological study of the effects of stream pollution conducted by Dr. Ruth Patrick, a stream ecologist at the Academy of Natural Sciences in Philadelphia.[65] Patrick's approach, which she called biodynamics, postulated that a healthy stream would support a wide diversity of life forms, while polluted streams would experience a significant reduction in species. Her first study—of the Conestoga Creek in Lancaster County, Pennsylvania—indicated the general validity of the method.[66]

60. DuPont news release, 10 April 1952, Accession 1410, box 42, Hagley Museum and Library [hereafter cited as Public Affairs Files].

61. *DuPont Company Annual Report*, 1952.

62. DuPont news release, 20 March 1957, Public Affairs Files.

63. W. T. Wood, "DuPont Water and Air Pollution Control," 20 Aug. 1965, Public Affairs Files.

64. Willem Rudolfs, "The Problem," in *Industrial Wastes: Their Disposal and Treatment*, ed. Willem Rudolfs (New York, 1953), quotation at p. 3.

65. Telephone conversation with Ruth Patrick, 30 Sept. 1999.

66. Ruth Patrick, "Biological Measure of Stream Conditions," *Sewage and Industrial Wastes* 20, no. 7 (July 1950): 926–38.

The following year, DuPont hired Patrick to conduct a similar set of tests in the Delaware River near the company's massive Chambers Works (which was later labeled the single largest producer of hazardous wastes of any chemical plant in the United States).[67] Her study showed the "effect of wastes discharged . . . to be confined mainly along the shore adjacent to the plant. Conditions a mile below the plant site were discovered to be the same as those [several miles above the plant.]" The healthier waters supported blue crabs and six species of fish. The report also noted, however, that nowhere was the river truly healthy.[68] In the next few years, Patrick did studies of streams in Texas on two properties where DuPont was constructing plants, at one of which—the Beaumont site—DuPont also did a survey of plant life and documented the site with motion pictures, should controversies arise in the future.[69]

At the other end of the spectrum, DuPont installed biological waste treatment facilities at several plants, a catalytic process to break down toxic methanol and ethylene glycol, and dug deep wells in Texas for the injection of waste salt water.[70] As company president Crawford Greenewalt explained in 1960 to a friend who was head of the Natural Resources Council of Maine, much of this activity was necessary because, "As a manufacturer and user of a wide variety of chemicals, some new and not widely understood, DuPont has had some unusual problems. Because of this, considerable attention has been given to waste disposal."[71] The company required that a statement on pollution accompany every major request for construction funding, and Greenewalt noted that proposals had been rejected because insufficient consideration had been given to pollution control. Moreover, DuPont did not count pollution investment costs against the profitability of a plant.

Despite these accomplishments and policies, the company still believed that "pollution cannot be abolished but it can be largely controlled to prevent it from becoming too large a problem."[72] Increasingly, industry was beginning to fear that abolition was exactly what was going to be required. DuPont public relations releases, which long had been upbeat and positive, now began to engage in hyperbole: "Undesirable as it is, pollution could be wiped out only by

67. Sarokin, *Cutting Chemical Wastes*, 59.

68. DuPont news release, 21 July 1949, Public Affairs Files.

69. DuPont news release, 10 April 1952, Public Affairs Files.

70. Public Relations Department, "Pollution Abatement," Feb. 1961, Public Affairs Files.

71. M. F. Wood to Robert W. Patterson, 12 Sept. 1960, Accession 1814, box 13, Hagley Museum and Library.

72. "Pollution Abatement."

abandoning our living standards, dispersing our population, and, in effect, returning the land to the Indians."[73] Pollution, apparently, had become the handmaiden of progress.

Water Pollution as a Federal Priority

In spite of the growing apprehension within the chemical industry, there did not appear to be any emerging national consensus on the pollution issue in the early 1960s. The First National Conference on Water Pollution, held in Washington, D.C., in December 1960, attracted 1,200 representatives from industry, all levels of government, civic groups, education, sanitary engineering, and water resource development. Proposals ranged from Health, Education, and Welfare Secretary Arthur S. Flemming's push for more federal regulatory power to Oklahoma Senator and oil magnate Robert S. Kerr's suggestion for the creation of a popular symbol—a mermaid with a broom—to increase public awareness just as Smokey the Bear had done for forest fires. Four panels discussed the various aspects of the issue and compiled a list of recommendations that reiterated many points made since the 1930s: further evaluation of the problem, expansion of treatment facilities, importance of recreation value, increased public awareness, collecting data on toxicity, financial incentives for industry, and development of water quality criteria. At the level of practice, a great deal of research and development was needed to solve specific pollution problems.[74]

In contrast to the growing concern about pollution in the 1950s, public investment in R&D was minimal. The Cold War had brought massive government support for the aerospace and electronics industries, while research on pollution and its abatement was much lower on the list of even the relatively small budget of the National Science Foundation. For fiscal year 1957, the U.S. Public Health Service asked for $1.3 million for research and data collection on water pollution, which Congress cut back to $300,000 for the University of Cincinnati's Sanitary Engineering Center.[75] The launching of Sputnik in October 1957 did little to encourage spending on pollution problems. At the 1960 Water Pollution Congress, academic researchers requested

73. Ibid.

74. "First National Conference on Water Pollution," *Industrial Water and Wastes* (Jan.-Feb. 1961), 28–31.

75. "US Pollution Research Goes on Ice," *Chemical Week* (11 Aug. 1956), 56–57.

$10 million annually for water pollution R&D alone. A National Research Council scientist pointed out the dearth of sanitary engineering programs and graduates.[76]

Pollution control techniques and processes were technically challenging and expensive. The great diversity of waste products prevented the adoption of generic—and hence relatively inexpensive—solutions to problems. In 1947, Sheppard Powell pointed out that manufacturers who had hastily put in equipment to meet regulatory deadlines often discovered that the equipment did not solve the problem.[77] DuPont's Jacobs, in his 1955 review of waste treatment methods, noted that

> there are some problems which can be solved quite readily by fairly simple means, but there are others which cannot yet be treated economically by any known means, although studies in connection with them have been carried out for years. . . . Industrial waste treatment problems are not solved by picking ready-made treatment processes off the shelf. In most cases, small scale experiments should be made before the final treatment equipment is installed.[78]

A major cooperative R&D enterprise was probably necessary to solve these myriad problems, but government involvement increased only cautiously.

Federal involvement in water pollution issues, initiated in 1948 with the Water Pollution Control Act, was reinforced by the 1956 act. As one of the sponsors of the bill recalled:

> We knew that the pollution problem was running far ahead of our knowledge of what clean water really meant, that we were not sure how to correct new sources of contamination, and that the federal role of overseer . . . would need much more emphasis. We knew also that higher appropriations were needed everywhere for anti-pollution systems and construction.[79]

The 1956 act did not adequately address the problem, and Dwight Eisenhower vetoed a bill to supply more funding in 1959.[80] Under post-Sputnik pressure to increase military spending, he tried to keep the lid

76. "First National Conference on Water Pollution."
77. Powell, "Creation and Correction of Industrial Wastes."
78. H .L. Jacobs, "Waste Treatment Methods—Recovery and Disposal," *Chemical Engineering* (April 1955), 188.
79. Blatnik, "History of Federal Pollution Control Legislation," 2–3.
80. Ibid., 2–4.

on other parts of the budget. But the new Democratic administration, elected in 1960, did not share Eisenhower's fiscal conservatism and proceeded to increase federal spending, with John F. Kennedy's space program being the most dramatic example.

Soon after his inauguration in 1961, Kennedy supported amendments that increased funds available for municipalities and for the first time allocated significant funds, $25 million, for research.[81] Universities now began to delve into environmental science and technology. The publication of Rachel Carson's *Silent Spring* in 1962 provided a model for studying the interaction of chemicals and the environment and greatly increased public interest in the issue.

Politicians noticed this growing interest in chemicals and the environment. The *Wall Street Journal* reported that Kennedy, as part of his 1964 reelection campaign, was going to condemn eighty specific enterprises as polluters of air and water. The publication *Practical Public Relations* warned that polluting companies had better do something about it soon, because if they did not, "the penalty will be an aroused public, and a public aroused can be a fearsome thing."[82] Following Kennedy, Lyndon Johnson made pollution control part of his Great Society program. The Water Quality Act of 1965 and the Clean Water Restoration Act of 1966 each marked new directions in federal oversight and sponsorship. The former was an extension of the 1948 and 1956 acts, but it also provided for the establishment of the Federal Water Pollution Control Administration and the setting of water quality standards for interstate waters. The Clean Water bill addressed the underfunding of municipal waste treatment. Since 1956, the federal government had invested $678 million in sewage treatment, while local communities had spent $2.5 billion. The new bill allocated $3.9 billion to be spent over five years.[83] By the early 1970s, the old problem of untreated sewage finally would be brought under control. Industry spending on treatment and disposal paled in contrast to the vast sums being spent on the simpler problems of domestic wastes. In 1958 the MCA reported that only 2 to 5 percent of the cost of new chemical plants was attributable to pollution control.[84]

As the public sector cleaned up its waste, industrial pollution became the major obstacle to cleaner water. Treating industrial wastes

81. Ibid.

82. "What's Your Firm Doing About the Problem of Pollution?" *Practical Public Relations* 9, no. 5 (May 1964): 3, Public Affairs Files.

83. Blatnik, "History of Federal Pollution Control Legislation."

84. These figures are cited in M. F. Wood to Robert W. Patterson, 13 Oct. 1960, Accession 1814, box 13.

was generally more complicated than dealing with domestic sewage, however, and it was becoming more so because of the growing concerns about toxicity.

Public concern over the toxic aspects of chemicals appears to have focused primarily on food adulteration and contamination. Lead arsenate pesticide residues on fruits became a *cause célèbre* in the 1930s; ironically, one defender of pesticide use stated that ten glasses of water could contain as much lead as one apple.[85] A growing consumers' movement drew attention to the use of many untested chemicals in food, medicines, and cosmetics. At this point, toxicological testing was being done in only a few chemical company and private laboratories, but interest was increasing. In 1954, *Fortune* published an article, "Making Synthetics Safe," on the occasion of the dedication of DuPont's newest toxicology lab.[86] The article stated that American industry was spending $15 million per year on toxicology, but the expensive and time-consuming nature of animal testing meant that only a small percentage of new and old chemical products were being tested. Nevertheless, animal testing for potential cancer-causing chemicals had flourished in the 1940s, and by 1951 the U.S. Public Health Service had identified 1,329 suspect chemicals.[87] The growing number of lung cancer cases also focused attention on environmental carcinogens.

What is most interesting is that this *Fortune* article contains a clear statement of the critique of chemicals that became prevalent in the late 1960s:

> From both coal tar and petroleum, compounds have been extracted that are capable, in trace quantities, of causing cancer. This discovery casts an element of doubt over the whole range of synthetic plastics, fibers, detergents, etc. . . . Americans are beginning to live their lives in constant contact with a veneer of synthetic materials, many of them unknown a decade ago. . . . The concern, now, is that the human race is slowly poisoning itself by the sheer number and variety of new, synthetic chemicals found in food, drugs, and cosmetics.[88]

The concerns expressed in this article do not, however, seem to have alarmed the public, experts, or industry.

85. Whorton, *Before Silent Spring* (Princeton, N.J., 1974), 184.

86. "Making Synthetics Safe," *Fortune* (Oct. 1954), 138–41, 171.

87. Christopher Sellers, "Discovering Environmental Cancer: Wilhelm Hueper, Post-World War II Epidemiology, and the Vanishing Clinicians Eye," *American Journal of Public Health* 87, no. 11 (Nov. 1997): 1829.

88. "Making Synthetics Safe," 138–41, 171.

A 1965 public opinion poll conducted for industry by Opinion Research Corporation indicated that Americans were not very concerned about pollution and that 70 percent of them would not spend $100 a year for cleaner air and water. Only 15 percent of those polled selected air and water pollution as among the nation's top three or four problems.[89] The public, however, did associate the chemical industry with pollution and was unaware that the industry was implementing any abatement measures. Because 70 percent of the CEOs polled believed that their companies were doing a great deal to control pollution, the pollsters suggested that the industry could do a better job of publicizing its efforts. Interestingly, over half of the CEOs polled believed that pollution control demands made by federal officials were realistic.[90] Nevertheless, chemical company CEOs were not very enthusiastic about significantly increasing spending on pollution control. Wall Street analysts were beginning to call the industry mature, and profits and prices were falling.[91]

Not long after this poll, the American public did become aroused by the issue of industrial pollution. Events such as the Santa Barbara oil well blowout, fish kills by thermal shock from nuclear power plant cooling water, the use of chemicals such as napalm and Agent Orange in Vietnam, and the development of academic environmental science helped to create a sense of a national environmental crisis. Earth Day in 1970, and Barry Commoner's *The Closing Circle: Nature, Man & Technology*, published the following year, coalesced these diverse concerns into a comprehensive environmental worldview: human technologies had become so powerful and pervasive that they were interfering with the earth's delicately balanced ecology. The concept of mutually dependent biological systems created a rationale for the defense of nature locally as well as globally. Supported by this very popular ideology, an activist federal government enacted major pollution control legislation in the late 1960s and into the 1970s.[92]

The chemical industry complained that this torrent of legislation at both the state and federal levels was too much, too fast. In 1967, states alone passed 112 pollution laws. The overlapping, and often conflicting, jurisdictions of numerous pollution-control agencies pushed some

89. The top three concerns were juvenile delinquency (40%), unemployment (37%), and lack of recreational facilities (30%).

90. Opinion Research Corporation, "Public and Executive Views on Air and Water Pollution Control," Sept. 1965, in Public Affairs Files.

91. Hounshell and Smith, *Science and Corporate Strategy*, chaps. 22 and 25.

92. Kian Esteghamat, "Structure and Performance of the Chemical Industry under Regulation," in *Chemicals and Long-Term Economic Growth*, ed. Ashish Arora, Ralph Landau, and Nathan Rosenberg (New York, 1998), 341–45.

industry leaders toward support for a uniform national set of regulations.[93] Underlying the new debates were the old problems of how much abatement should be achieved, at what cost, and at whose expense. If complete treatment of wastes were required, the chemical industry, which in 1970 had an income of about $50 billion, yielding pretax profits of about $5 billion, would not have been able to afford compliance. If the cost of cleaning up industrial pollution was still in the range of earlier estimates of one percent of GDP, then the cost in 1970 was $10 billion, of which the chemical industry might have been expected to pay somewhere between one-half and three-quarters.[94] By the late 1970s, chemical industry pollution control investment represented 10 percent of the annual totals, running close to $1 billion.[95] In 1990, chemical industry pollution-related spending was estimated at 3.5 percent of value added, or about $3 billion. Dow estimated that investments in environmental safeguards added 3 percent to its prices. With net profits of less than 10 percent of sales, these costs are significant.[96] Yet, while spending has been significant, it has not proven crippling for the chemical industry. In response to legislation, the industry has increased pollution spending several fold, though not by orders of magnitude. How much more could have been expected from an increasingly mature industry is unclear.

Conclusion

Beginning in the 1930s, the chemical and other industries and the government began to assess and ameliorate the effects of pollution. Given the variety of problems and limited technology, overall costs were estimated to be very high. Industry proceeded to invest in mon-

93. "Pollution Control Laws: Haste Does Not Make Waste Control," *DuPont Newsletter* (June 1968), 3–4.

94. In 1984, the Environmental Protection Agency estimated that the organic chemical sector alone accounted for almost 40 percent of air emissions of selected chemicals from industrial sources and 83 percent of hazardous organic industrial discharges to rivers. Sarokin et al., *Cutting Chemical Wastes,* 3.

95. Kikor Bozdogan, "The Transformation of the US Chemicals Industry," in *The Working Papers of the MIT Commission on Industrial Productivity* (Cambridge, Mass., 1989), quotation at p. 88. By 1970 DuPont had invested $125 million in pollution control equipment, representing 2 percent of its total. Pollution-related operating costs were $26 million per year, about 8 percent of net profits. In 1971, the company announced that it would spend $300 million—split equally between investment and operating costs—over the next three years. See DuPont News Release, 22 March 1971, Public Affairs Files.

96. Esteghamat, "Structure and Performance," 354–55.

itoring and abatement at levels that did not significantly affect economic indicators of performance. With respect to water pollution, problems such as untreated municipal sewage and coal mine runoff undermined chemical industry incentives to invest heavily in cleaning up its own effluents. Beginning in the 1950s, concerted efforts at sewage treatment by localities and the federal government began to make significant strides, though massive federal assistance did not occur until 1966. During the rapid years of expansion of the chemical industry in the 1950s and 1960s, Cold War pressures led the federal government to spend vast sums of money on defense-related industries but little on pollution-related research and development or abatement. In the late 1960s—when cleaner air and water became national priorities—not enough preliminary R&D had been done to allow quick and efficient application of control technology or substitution of less polluting processes and products. Even with regard to cleaning up old pollution, less than $10 billion has been spent on designated sites through the 1990s.[97] Compared to expenditures on Ronald Reagan's Star Wars system or the savings and loan bailout, pollution control has not been a major government expense.

Overall, the anger and blame that environmental historians have directed at the chemical industry seem unwarranted. The problems were difficult to define and, once defined, expensive to solve. The public, local governments, and the federal government all were willing to do very little to address the issue. Chemical pollution was unsightly and it sometimes killed fish, but it was scarcely viewed as "environmental havoc" until recent decades.

97. Ibid., 349.

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